In the Description:

[0001] The present disclosure relates [~~inventions relate~~] generally to wireless communications, and more particularly to incoming message decoding in wireless communications devices capable of receiving information transmitted in portions over successive intervals, for example, cellular communications handsets that receive messages transmitted in a series of bursts over consecutive TDMA time frames, methods and apparatuses therefor.

[0003] It is known to conserve power in wireless communications devices operating in idle mode when not communicating by configuring radio circuits and a digital signal processor (DSP) in [~~a~~] sleep mode. The microprocessor control unit (MCU) wakes-up the radio circuits and the DSP from [~~the~~] sleep mode with a command when it is time to receive [~~the~~] incoming data bursts, which are transferred to the DSP from the radio circuits. The radio circuits and DSP must remain awake to receive all data bursts in each [~~the~~] data block, for example, during the 1st, 2nd, 3rd and 4th time frames of a CCCH message. A command from the MCU on the final burst instructs the DSP to decode the PCH burst data. After the DSP decodes the burst data received, the DSP sends the decoded data to the MCU.

[0004] U.S. Patent No. 5,570,369 entitled "Reduction of Power Consumption In A Mobile Station" discloses attempting to recover data bits of a four-burst message by de-interleaving data from at least [~~the~~] 1st and 2nd bursts while assuming that data from the remaining bursts of the message are

unreliable. The de-interleaved data bits are de-convoluted with a Modified Selective-Repeat Type-II Hybrid ARQ based de-convolution algorithm, and the result is FIRE decoded in an effort to reconstruct the original information. If reconstruction is unsuccessful, then [~~the~~] a 3rd data burst is received and the de-interleaved data bits thereof are combined with the de-interleaved 1st and 2nd data bits, and the combined data bits are de-convoluted with a Viterbi algorithm before FIRE decoding. Power consumption of the device is reduced by operating radio circuits of the mobile station in sleep mode during the time frames when the 3rd and/or 4th bursts are transmitted if the original information may be reconstructed with only two or three data bursts. The methods of U.S. Patent No. 5,570,369 require receiving at least the 1st and 2nd bursts of the four-burst PCH or BCCH message transmitted.

[0005] The various aspects, features and advantages of the present invention will become more fully apparent to those having ordinary skill in the art upon careful consideration of the following Detailed Description [~~of the invention~~] with the accompanying drawings described below.

[0007] FIG. 2 is an exemplary process flow diagram [~~for one aspect of the invention~~].

[0010] FIG. 5 is an exemplary process flow diagram [~~for another aspect of the invention~~] where there is a not a likelihood that the incoming message corresponds to a known message.

[0011] FIG. 6 illustrates a multi-frame message having data in [~~the~~] 1st and 2nd frames and unreliable data in [~~the~~] 3rd and 4th frames.

[0012] FIG. 1 is a mobile wireless communications device 100 capable of receiving incoming messages transmitted in a series of portions over successive intervals, for example, a wireless GSM cellular communications handset capable of receiving incoming messages transmitted in a series of bursts over consecutive TDMA timeframes. The [~~invention~~] disclosure is applicable more generally to any receiver that receives information in portions in successive time intervals.

[0013] The device 100 comprises generally a transceiver 110 coupled to a processor 120, which includes a micro-controller and in some preferred embodiments a digital signal processor (DSP). Memory 130, for example a ROM, RAM and in some embodiments a PROM, is coupled to the processor. The exemplary device 100 also includes a visual display device 140, for example, an LCD display, coupled to the processor. The device also includes input devices 150, like a microphone, keypad and other inputs, and output devices 160, including a loudspeaker, audio output connectors, etc.

[0015] In one embodiment, the message is a paging message. In the GSM communications networks, for example, the device 100 receives Paging Channel (PCH) information transmitted in a series of four bursts in corresponding time-slots of consecutive CCCH frames. The PCH is a control channel used for paging a mobile station (MS) when there is an incoming call addressed to the MS. Every message on the PCH channel addressed to an MS

contains the paged MS identity number, or the International Mobile Subscriber Identity (IMSI), or Temporary International Mobile Subscriber Identity (TIMSI). In the case where no MS is being paged, a "No Identity Page" or like message is sent on the PCH channel. At the mobile device, the decoded PCH burst data may indicate that the MS is being paged, or that another MS is being paged, or that no MS is being paged. Thus in some instances, the paging message is addressed to the MS, or a paging message is not addressed to any device, also referred to herein as a "No Identity Page". In other applications or embodiments, however, the message may be some message other than a paging message, and thus this aspect of the [~~invention~~] disclosure is not limited to paging messages.

[0017] FIG. 3 is a more detailed burst data reception and decoding process flow diagram according to an exemplary embodiment [~~of the invention~~]. At block 310, a single burst is received for a first time frame. At block 320, after demodulation, incoming data bit detection occurs at block 320 in a channel equalizer. During equalization, the transmitted bit sequence is reproduced from the demodulated burst.

[0024] In another alternative embodiment, incoming data from the 3rd time frame 416 may be combined with known data from the 1st, 2nd and 4th time frames, thus permitting reducing power consumption during the 1st and 2nd time frames 412 and 414. The reception of incoming bursts of the 3rd time frame without receiving bursts of the 1st and 2nd time frames is preferably performed only when the channel quality is sufficiently good to ensure valid decoding of the incoming message with the incoming data of not more than

the [~~2nd~~] 3rd through the 4th time frames in the event that the incoming message does not correspond to the known message, or in the event that the incoming message cannot be decoded validly with the data from only the 3rd time frame.

[0027] In some embodiments, where MS processing capacity permits, the incoming data portion [~~from~~] may be compared in parallel with corresponding portions of more than one known message, for example a "No Identity Page" and a page addressed to the MS, among other known messages.

[0029] In FIG. 5, at block 510, a 2nd burst is received, and at block 520 incoming data from the 2nd burst is recovered by the equalizer and subject to the deinterleaving operation. Thereafter, incoming data from the 1st and 2nd time frames [~~is~~] are decoded. The data for the remaining time frames not yet received, e.g., the 3rd and 4th time frames, is marked as unreliable prior to decoding. FIG. 6 illustrates a four-frame message 600 having data bits in the first and second frames 610 and 620, but no data bits in frames 630 and 640, which are designated as having unreliable bits prior to deinterleaving and decoding.

[0032] In one embodiment, the radio circuits are operated in reduced power consumption mode during the 1st interval or time period of the data transmission, and the 1st burst received is in the 2nd time frame. In this alternative embodiment, after an [~~unsucceesful~~] unsuccessful comparison with any known data as discussed above, the 2nd burst received at block 510 is in the 3rd time frame, and any subsequent burst received is in the 4th time frame, which is the last time frame for CCCH frames in GSM networks. According to

this embodiment, the radio circuit will operate at most for three of the exemplary four time frames, and in some instances the radio circuits may operate for only two of the four time frames, i.e. the 2nd and 3rd time frames, if decoding is successful for incoming data from only two received bursts. This mode of operation will be reliable only where and when channel conditions are optimum, but will provide substantial power savings.

[0033] In another alternative embodiment, the 1st burst received is in the 3rd time frame, and any subsequent 2nd burst received, at block 510 in FIG. 5, is in the [~~3rd~~] 4th time frame. The radio circuits are operated in reduced power consumption mode during the 1st and 2nd intervals or time periods of the data transmission. According to this embodiment, the radio circuit will operate at most for two of the exemplary four time frames, i.e., the 3rd and 4th time frames, if decoding is successful for incoming data from only two received bursts. If decoding is unsuccessful, the MS must wait for the next message transmission. This mode of operation will only be viable where channel conditions are optimum, but will provide substantial power savings.

[0036] The present [~~inventions~~] disclosure thus [~~provide~~] provides methods for significantly reducing power consumption in radio receivers by operating in reduced power consumption mode when it is unnecessary to receive burst data. The processing of received data portions is streamlined by determining first whether the likelihood that an initial incoming data portion corresponds to a known data portion, and where the likelihood is good reconstructing and validating the message by combining the received data portion with other known data portions of the known message. If the

likelihood is not good, additional data portions are received and the message is decoded with the assumption that any data portions not yet received are invalid. The process repeats until decoding is successful, which may be verified by a CRC operation. The [~~inventions are~~] disclosure is applicable to any communications system that receives message in portion transmitted over successive interval, for example GSM communications.

[0037] While the present disclosure [~~inventions~~] and what is considered presently to be the best modes thereof have been described in a manner that establishes possession thereof by the inventors and that enables those of ordinary skill in the art to make and use the [~~inventions~~] same, it will be understood and appreciated that there are many equivalents to the exemplary embodiments disclosed herein and that myriad modifications and variations may be made thereto without departing from the scope and spirit of the inventions, which are to be limited not by the exemplary embodiments but by the appended claims.